# Low-speed Serial Data Trigger, Decode, Measure/Graph, and Eye Diagrams



*Teledyne LeCroy's Trigger (T), Decode (D), Measure/Graph (M or G) and Eye Diagram and Physical Layer (E or P) options are the best in the industry and nearly universally available across the entire Teledyne LeCroy oscilloscope product line.*

## Key Features

### More than 20 supported standards:

- I²C
- SPI, SPI DDR, Simplified SPI
- UART and RS-232
- USB 1.x, 2.0 and USB 2.0 HSIC
- CAN and CAN FD
- LIN
- FlexRay
- SENT
- ARINC 429
- MIL-STD-1553
- SPACEWIRE
- 10/100 Base-T Ethernet, EtherCAT
- DPHY
- DigRF 3G, DigRF v4
- I²S, incl. LJ, RJ, TDM
- Manchester
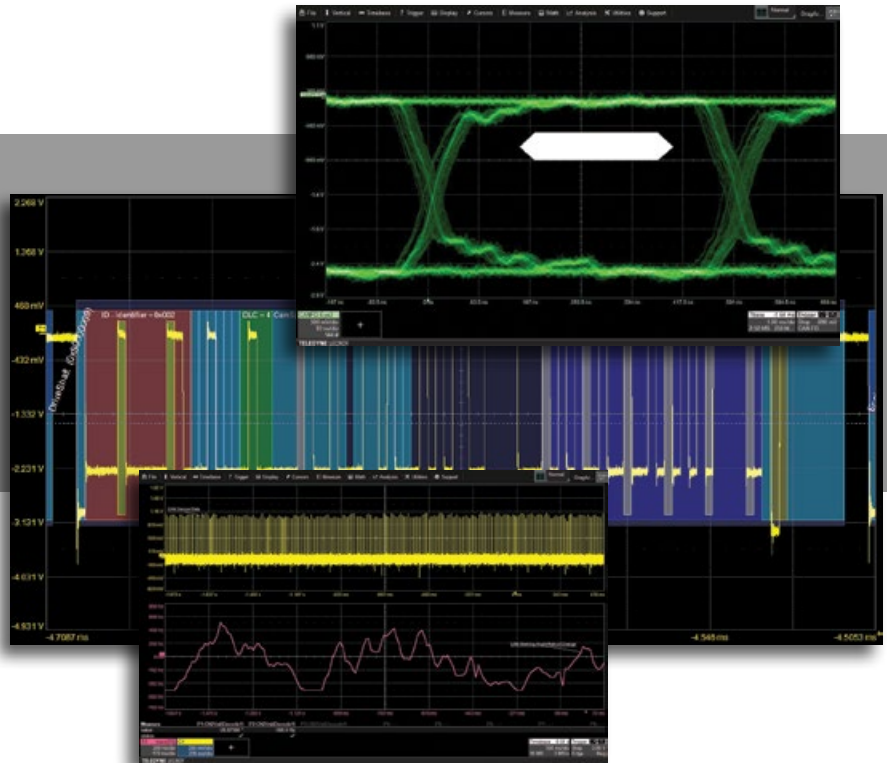- NRZ

**Most powerful, flexible triggering capabilities**

**Intuitive, color-coded decode overlays**

**Single protocol results table supports up to 4 decoders at one time**

### Unique measure/graph capabilities:

- Automated timing measurements
- Serial DAC - extract digital data and plot it as a waveform
- Bus parameters

**Physical layer eye diagrams**

## Highest Performance Triggers

Designed by people who know the standards, with the unique capabilities you want to isolate unusual events. Conditional data triggering permits maximum flexibility, and highly adaptable error frame triggering is available to isolate error conditions. Frame definition allows grouping of UART or SPI packets into message frames for customization.

## The Best Serial Decoder

Decoded protocol information is color-coded to specific portions of the serial data waveform and transparently overlaid for an intuitive, easy-to-understand visual record. All decoded protocols are displayed in a single time-interleaved table. Touch a row in the interactive table to quickly zoom to a packet of interest and easily search through long records for specific protocol events using the built-in search feature.

## Measure/Graph Tools for Validation Efficiency

Quickly validate cause and effect with automated timing measurements to or from an analog signal or another serial message. Make multiple measurements in a single long acquisition to quickly acquire statistics during corner-case testing. Serial (digital) data can be extracted to an analog value and graphed to monitor system performance over time, as if it was probed directly. Complete validation faster and gain better insight.

## Eye Diagrams & Physical Layer

Rapidly display an eye diagram of your packetized low-speed serial data signal without additional setup time. Use eye parameters to quantify system performance and apply a standard or custom mask to identify anomalies. Mask failures can be indicated and can force the scope into Stop mode.

**Every serial trigger we design exhibits deep knowledge of the standard. Most serial triggers work with digital (MSO) inputs, or the EXT input for the Clock line so as to conserve analog channels. Each serial trigger has some unique aspect for high performance, such as:**

- $I^2C$ **trigger permits triggering on data in a specific location of an up to 2048 byte** $I^2C$ **EEPROM read or write.**
- **UART or SPI bytes can be combined into a single "message frame" - trigger on custom protocols based on UART or SPI byte blocks.**
- **UART supports 9-bit "address" or "wakeup" mode triggering.**
- **CAN, CAN FD, LIN, FlexRay and MIL-STD-1553 permit conditional ID/Address triggering.**
- **CAN and CAN FD permit triggering symbolically using a DBC file.**
- **USB 2.0 and MIL-STD-1553 triggers permits complex transaction definition and triggering.**
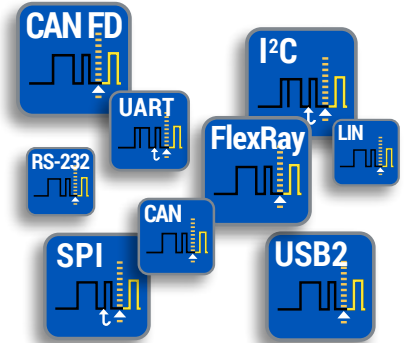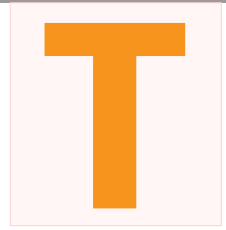
*High performance and a wide range of support for serial data standards*
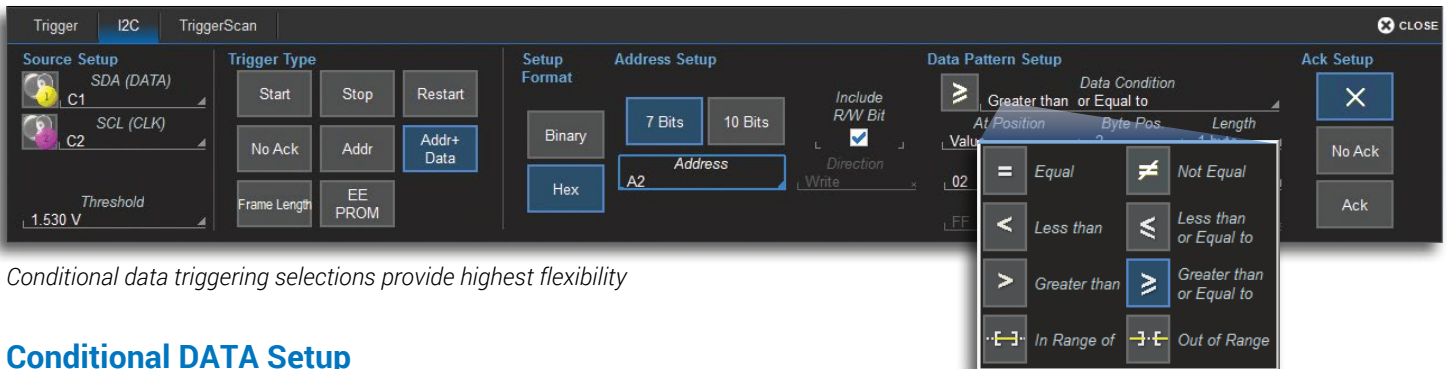
*Conditional data triggering selections provide highest flexibility*

## Conditional DATA Setup

Every Teledyne LeCroy low-speed serial trigger that incorporates DATA trigger permits a conditional (<. <=, =, >, >=, <>, inside a range, outside a range) setup for the DATA condition. This is especially useful in situations where abnormal events should be monitored, such as when a temperature sensor transmitting via $I^2C$ exceeds a maximum temperature, or a CAN node broadcasts a low or high engine RPM or coolant pressure.  Furthermore, data for triggering can be specifically isolated in very long byte streams to specific bit locations, even those which span data bytes.

## Support for Many Proprietary Protocols

Many proprietary serial protocols make use of the common UART (single Data line) or USART (Clock and Data lines, e.g., SPI) byte structures, with multiple bytes grouped into proprietary protocol definitions. Our highly flexible UART byte and SPI format definitions accommodate nearly any customer need, and the UART or SPI bytes can be defined to be part of a single "message frame" through use of our Interframe Setup. Then, the trigger pattern setup can isolate any byte value, e.g., an ID, or a DATA string value, that is part of your proprietary protocol message definition.
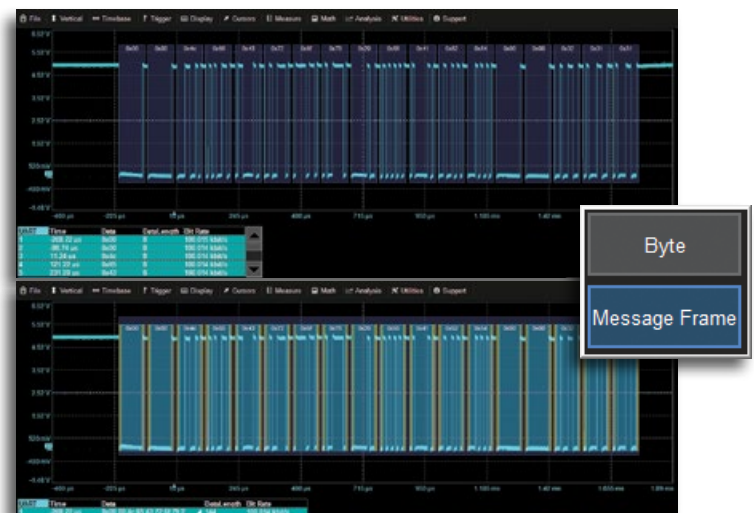
*Byte mode (top) treats each byte uniquely.  Message Frame mode (bottom) groups bytes into on single, long multi-byte message*

# SIMPLY THE BEST SERIAL DECODER

Our serial decode, search and table tools work exactly the way you want.  These tools are the industry standard for turning your oscilloscope into a protocol analyzer with fast and intuitive correlation of protocol data to the physical layer waveforms.

**D**

## Intuitive, Color-Coded Overlays

A transparent overlay with color-coding for specific portions of each protocol and the entire message frame makes it easy to understand your serial data information. Unlike other solutions, with protocol decode information away from the signal, our solution correlates the waveform and the protocol decode directly on the display. As the acquisition length is expanded or shortened, the decode overlay will adjust to show you just the right amount of information.
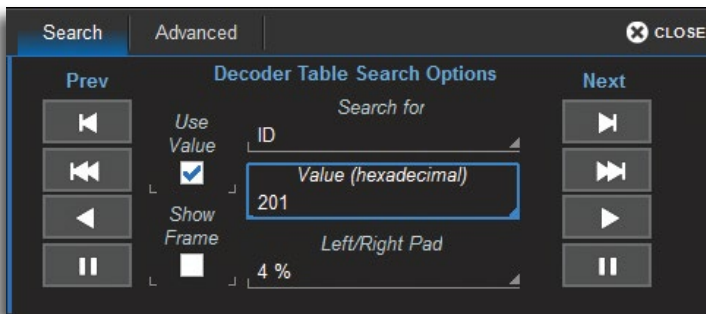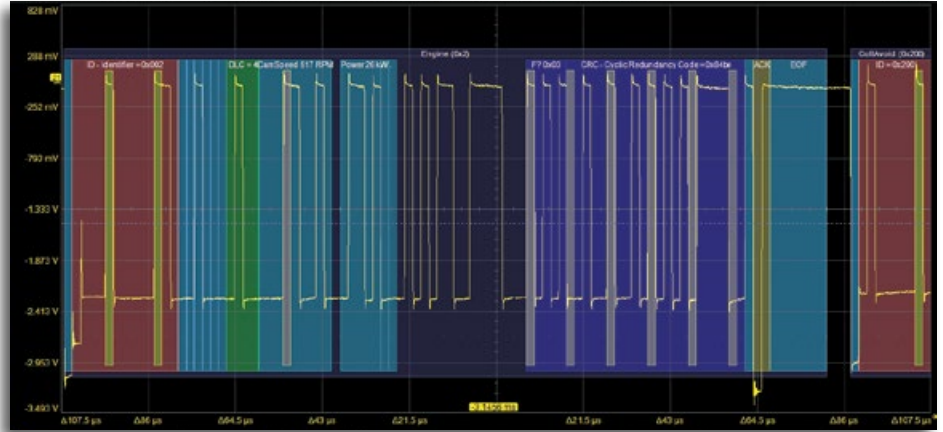


## Pattern Search



All decoders provide ability to search through a long record of decoded data by using a variety of search criteria, or values, or simply finding the next occurrence. Pattern Search automatically creates a zoom trace of the acquired waveform and displays the selected location complete with the transparent color-coded overlay.



## Interactive Table Summarizes Results

Turn the oscilloscope into a protocol analyzer with a tabular display of decoded information. Customize the table to show only the data of interest and touch a message in the table to automatically zoom to it and display it on the screen.  Export the table for offline analysis.  Up to four different decoded signals of any type may be simultaneously displayed in the table.

## Key Features

**Timing measurements**
- Serial Message to Analog Signal
- Analog Signal to Serial Message
- Serial Message to Serial Message

**Serial DAC measurement/graphing**

**Bus status measurements**

**Automated – quickly gather statistics, display Histograms**

**Quickly correlate cause-effect timing relationships to other events**

**Conditional filtering**

**Supported for**
- I$^2$C
- SPI, SPI DDR, Simplified SPI, Custom SPI
- UART
- RS-232
- USB 1.x and 2.0
- CAN
- CAN FD
- LIN
- FlexRay
- ARINC 429
- MIL-STD-1553
- DigRF 3G
- DigRF v4
- I$^2$S, incl. LJ, RJ, TDM (note: Serial DAC graph, or "G" capability only)

**The measurement and graphing capabilities significantly enhance our trigger and decode packages, and help you debug and validate faster.**

**Digital data can be extracted and rescaled to an analog value and graphed over time, time-correlated to other acquired data, as if you had probed it directly. It's a Serial Data DAC!**

**Automated cause-effect timing measurements can be made between analog signals and serial data messages, or two serial data messages. Use with serial triggering and long acquisitions to understand system behavior during stress or corner-case testing. A variety of bus status measurements are also available.**

**All measurements may be used with the rich set of standard Teledyne LeCroy standard parameter analysis tools, including automated pass/fail analysis with boolean test conditions, measurement gates, measurement accept, filtering, parameter math, and custom math.**
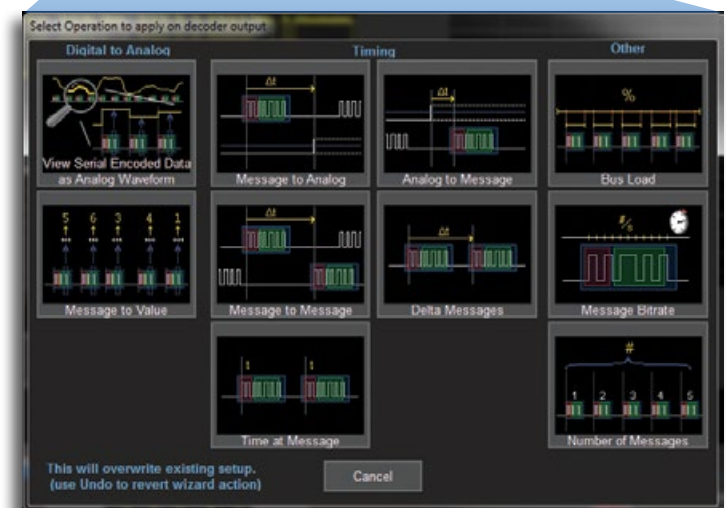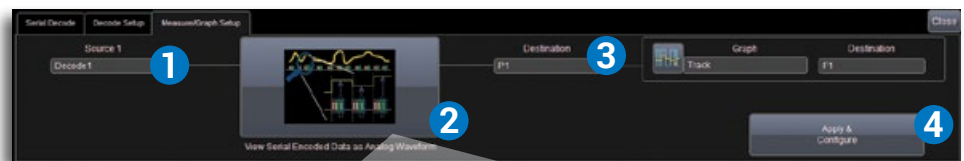




Setup is easy in the Measure/Graph setup tab:

1. Choose the source
2. Choose the measurement
3. Select the destination parameter (e.g., P2)
4. Then apply and configure

## Serial Data DAC and Graphing Tools

Digital data can be extracted from specific locations in the serial data message using the Message to Value measurement parameter - a serial data DAC. This information can then be displayed as a measurement parameter value(s), or it can be viewed as a time-correlated waveform displaying the measurement value over time - as if you were able to probe and acquire it directly. Use the long acquisition time of the oscilloscope to understand how the data changes over long periods of time, in conjunction with other system behaviors.

Some examples of the usefulness of this capability are:

- Viewing I$^2$C or SPI temperature sensor data
- Viewing DigRF 3G radio frequency I and Q modulated signals
- Viewing CAN wheel speed information used by an ABS
- Viewing reconstructed analog audio from serial I$^2$S streams
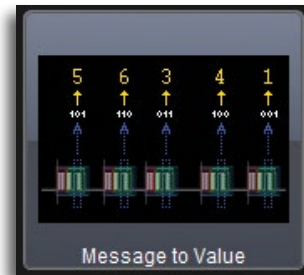
*Decoded data content of data payload of a protocol message meeting conditions.*
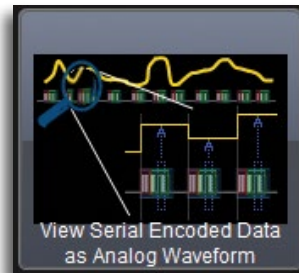
*Applies a Track math operator to the Message to Value measurement to view Serial Encoded Data as an Analog Waveform*
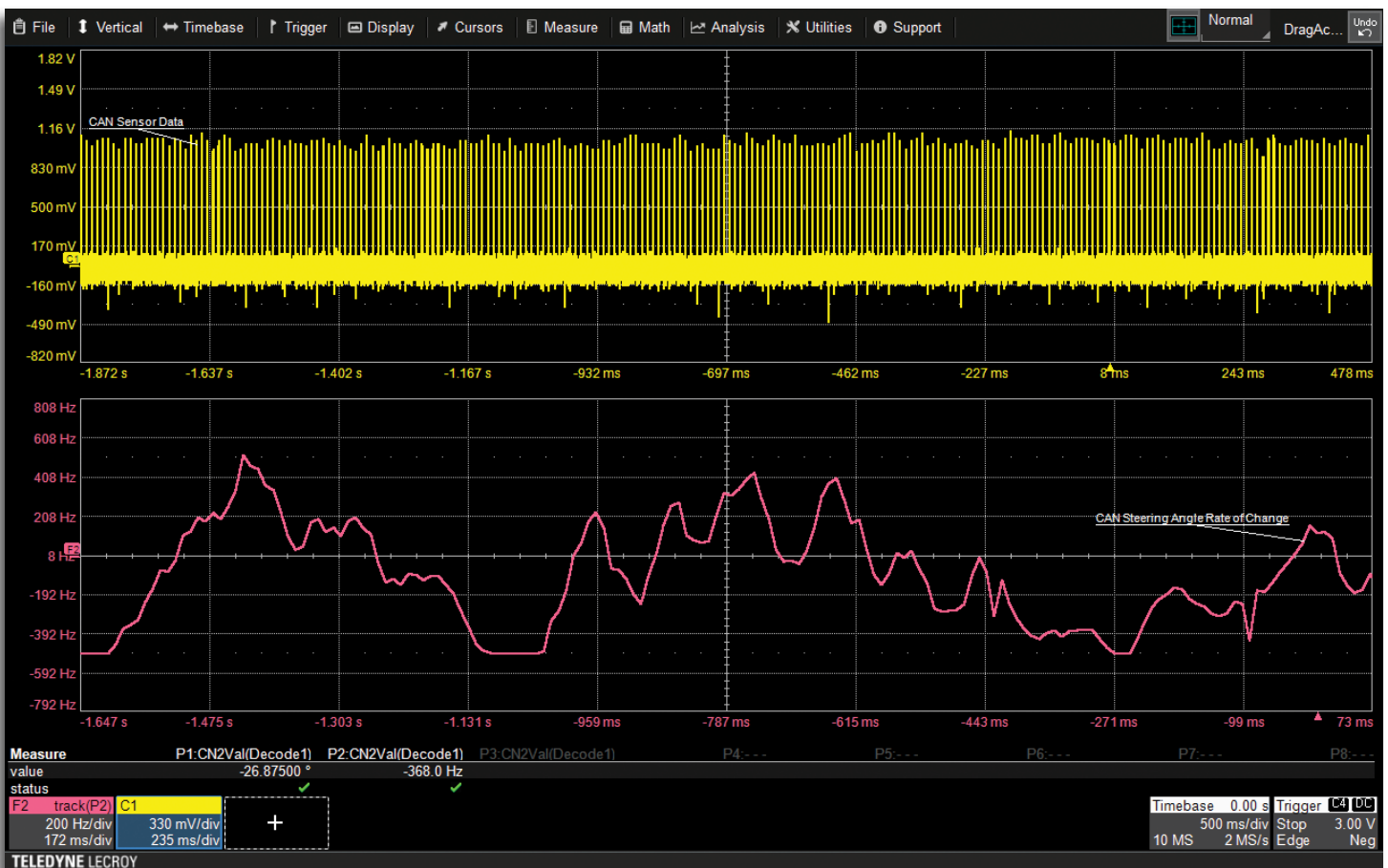
*Shown above is a long acquisition of a CAN serial data signal (top waveform) that contains embedded digital data for steering wheel angle rate of change (deg/s, or Hz). The Message to Value parameter was configured to locate and extract the digital steering wheel angle range data from particular locations in specific CAN serial messages, and then converted from digital to analog form with proper re-scaling and physical units. The serial data DAC waveform (bottom waveform) is shown in the lower grid.*

## Automated Timing Measurements

Utilize a serial trigger to isolate a specific message and then measure a cause-effect timing relationship with a subsequent analog signal, or vice versa. But instead of manually measuring the timing with cursors, use these tools to automate the measurement and return thousands of values quickly as your system undergoes stress testing. Automate the measurement and validation of gateway latency times from one serial message to another (e.g. CAN to LIN or low-speed CAN to high-speed CAN, or CAN to FlexRay) without having to manually use cursors or compare values and times in a protocol table. Quickly understand bus latency times or arbitration behaviors by measuring the difference between two messages on a single decoded waveform. Dramatically improve your validation efficiency and time to insight
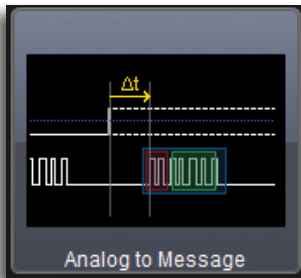


***Analog to Message***
*Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.*
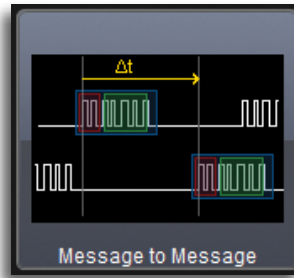


***Message to Message***
*Computes the time difference from a protocol message meeting specified conditions to another protocol message meeting specified conditions*
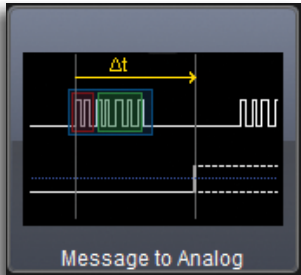


***Message to Analog***
*Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.*
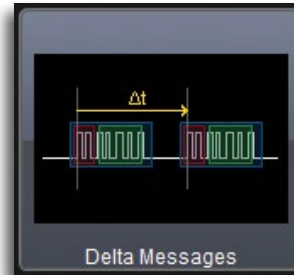


***DeltaMessage Time***
*Computes the time difference between two messages on a single decoded line.*
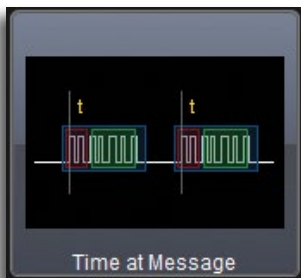


***Time@Message***
*Time from Trigger to each protocol message meeting specified conditions.*

*Use the Message to Analog measurement to find the time between an I²C data packet and a control signal on another channel. Multiple measurements in one or more triggers could be made to understand behaviors over time or under different operation conditions*

## Bus Status Measurements

The bus status measurements Bus Load, Message Bitrate, and Number of Messages, give an overall status of the decode protocol to quickly learn if the bus is over utilized and to verify the bit rate matches expectations.

**M**
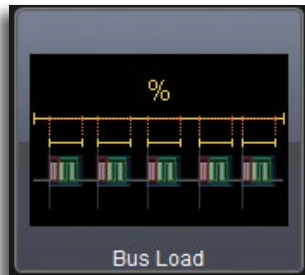


**Message Bus Load %**
*Computes the load of user defined message in percent on the bus*
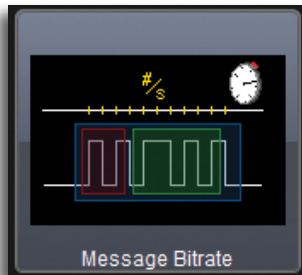
**Message Bit Rate**
*Computes the bitrate of the user specified messages on the decoded trace.*
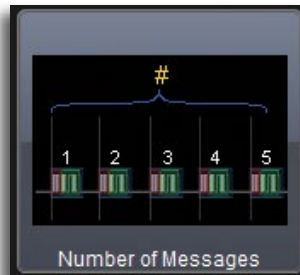
**Number of Messages**
*Computes the number of message matching user definition in a decoded trace.*

## The Perfect Oscilloscopes for the TDME Options

Teledyne LeCroy HDO and WaveRunner oscilloscopes are the perfect oscilloscope platforms to utilize the TD and TDME toolsets.

Teledyne LeCroy's HDO 12-bit oscilloscopes provide 12-bit resolution and either 4 or 8 analog input channels up to 1 GHz with MSO digital input options. These oscilloscopes are have powerful standard toolsets for debugging deeply embedded designs with analog, digital, serial data, and sensor signals. Their 12-bit resolution is ideal for measuring sensor signals and correlating them to other system activities. 8 analog input channels provides more ability to correlate more signals to each other.

Teledyne LeCroy WaveRunner oscilloscopes, such as the WaveRunner 8000 Series, are also extensively used for embedded system debug. Their standard toolsets complement the TDME packages extremely well.

**E**
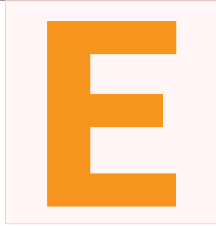
Eye Diagrams are "bit-sliced" views of the physical layer serial data waveforms. They provide a fast, intuitive way to understand physical layer signal integrity. Eye Diagrams may be combined with masks and mask failure indications, and eye (opening) parameters. Protocols with challenging topologies (e.g. FlexRay) provide even more advanced measurement capabilities.

## Key Features

**Up to four simultaneous Eye Diagrams**

**Simple to set up - one button push**

**Include standard or custom masks. Create your own masks.**

**Eye parameters**

**Mask failure indication**

**Failure locator trace waveform**

**Pass/Fail with STOP on failure**



*Eye diagrams "slice" each bit and overlay them to get a consolidated view of signal quality. Intrusions into the eye opening or onto a mask indicate potential problems.*



## Up to 4 Simultaneous Eye Diagrams

Up to four serial data signals can be decoded and displayed as eye diagrams at one time. These can be different protocols, or the same protocol measured at different points (e.g., transmit and receive, different nodes, or different standard-defined test points). Apply a user-defined filter to each eye diagram to only display specific signals in the eye.

| Height(Eye4) | Width(Eye4) | MaskHit(Eye4) |
|---|---|---|
| 1.84 V | 410.8 ns | 412 |
| ✓ | ✓ | ✓ |

## Eye Diagram Measurement Parameters

Quantify physical layer signal quality in the eye by applying parameters for Eye Height, Eye Width, and Number of Mask Failures. Some packages (e.g. FlexRay TDMP) go a step further and include additional measurements defined in the standard.

**E**

## Mask and Mask Failure Indication

A user-defined or pre-defined mask may be added to the eye diagram so as to objectively evaluate if the physical layer signal intrudes too far into the eye opening. Apply a filter to include or exclude specific messages from the Eye so as to determine failure source (e.g., messages from a specific node or with a specific ID). Mask failures are indicated with a red circle and can be displayed in a table. Touch the failure table to open a zoom of the failed area for further inspection
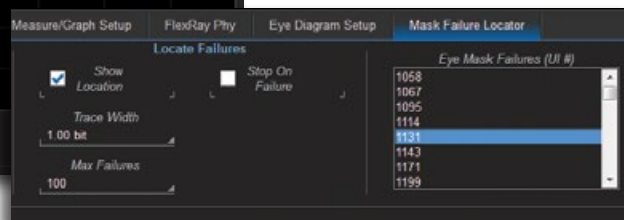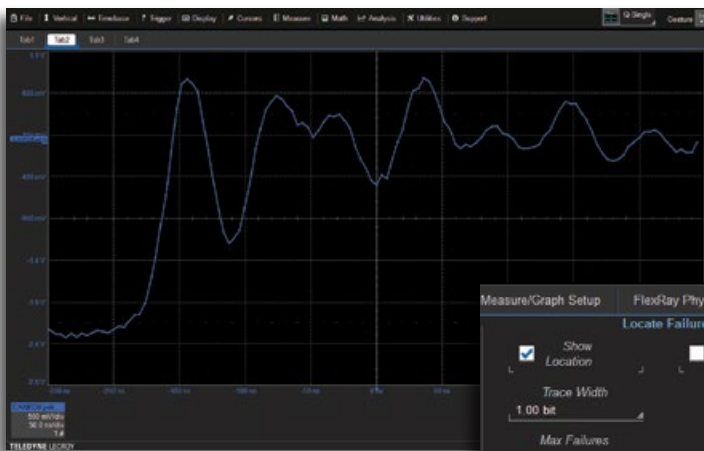




# PHYSICAL LAYER (EYE + ADVANCED MEASUREMENTS)

**P**



Some standards, due to their speed or nodal complexity, provide specific guidance on what eye diagrams or measurements should be made and exactly how they should be performed. FlexRay, and MIPI DPHY are examples. In these cases, the Eye Diagram ("E") capability is augmented with additional specialized "P" capability (for Physical Layer Measurements), per the standard. In these cases, the "E" capabilities previously described are also available.

# I²C

## Key Features

**Set an ACK condition (ACK, NO ACK, Don't Care) in all frame trigger setups**

**Does not require clock trace to be displayed during decode**

**EEPROM read/write 2048 byte trigger capability**

**Frame Length trigger capability**

**Address can include a R/W bit, or define as Don't Care**

**Use analog or digital (MSO) inputs for acquisition and triggering.**

**EXT input may be used for clock signal**



## More Trigger Choices

In addition to typical Start/Stop/ReStart, NoAck, Address and Address+Data triggers, Teledyne LeCroy provides triggering for EEPROM read/writes up to 2048 bytes long and for Frame Length. Address-based triggers permit an additional ACK condition (ACK present, NO ACK present, or DON'T CARE). and selection to include a R/W bit in a 7-bit trigger.



## More Flexibility for Address-based Triggers

Address-based triggers permit an additional ACK condition (ACK present, NO ACK present, or DON'T CARE). and selection to define the transfer direction as a READ, WRITE or DON'T CARE (using R/W bit in a 7-bit trigger, or R/W Direction selection in a 10-bit trigger).

| I2Cbus TD and I2Cbus TDME | |
|---|---|
| **Definition** | |
| **Source Setup** | Select Source for Clock and Data |
| **Trigger Capability** | |
| **Format** | Hexadecimal or Binary.  ADDRESS and DATA can be set up with different formats |
| **Trigger Setup** | Trigger on START, ReSTART, STOP, Missing ACK, ADDR, DATA, ADDR+DATA, ADDR+DATA FRAME LENGTH, EEPROM DATA TRANSFER |
| **ADDRESS Setup** | Specify one ADDRESS with condition of "=".<br>7 or 10 bit ADDRESS supported with full Read, Write, or R/W="Don't Care" selectability on both 7 and 10 bit ADDRESSes.<br>Choose to Trigger on address values that include/don't include R/W bit in address value. |
| **DATA Setup** | ADDRESS+DATA Trigger Type:<br>Hexadecimal: # Data Bytes = 0 to 12.  Data can be defined by nibble.<br>Binary: Any combination of 0,1, or X for 1-96 bits<br>Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.<br>ADDRESS+ DATA FRAME LENGTH Trigger Type: # Data Bytes = 0 to 2047.<br>EEPROM DTA TRANSFER Trigger Type:<br># Data Bytes = 0 to 12.  Data can be defined by nibble.<br>Data pattern can be set to start at the beginning of any byte in an up to 2048 byte sequence. |
| **DATA Conditions** | <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE |
| **ACK Conditions** | For any ADDR, ADDR+DATA, ADDR+DATA FRAME LENGTH, or EEPROM DATA TRANSFER setup, select an ACK Condition of ACK, NO ACK, and DON'T CARE. |
| **Bit Rates** | Full range over I2C specification for Standard, Fast, Fast-Mode Plus, and High-Speed modes.  Auto-detected. |
| **Trigger Input** | Any analog Channel or Digital input, or the EXT input.  Clock may be input to EXT to conserve available analog Channels. |
| **Decode + Search Capability** | |
| **Format** | Hexadecimal, Binary, ASCII |
| **Decode Setup** | Threshold definition required.  Default is to Percent amplitude.<br>Choose to Decode address values including/not including the R/W bit in address value. |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace.<br>Clock channel may be turned OFF and data will still decode (reduces screen clutter) |
| **# of Decodes** | Up to 4 buses may be decoded at one time.  In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color Coding for FRAME, START/ReSTART bit, ADDR, R/W, DATA, ACK, NACK, and STOP bit.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information.   Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search for Previous or Next ADDRESS, PACKET, or DATA in hexadecimal format. |


| I2Cbus TDME only | |
|---|---|
| **Measure / Graph Capability** | |
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.<br>**Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog**, **Analog to Message**, **Message to Message**, **ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) measurement parameters.<br>Serial Message may be defined by "ID =" (where applicable) and user-defined DATA condition of <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages**, **Message Bit Rate**, **Message Bus Load %**:<br>Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

# SPI



## Key Features

**Supports nearly any type of SPI, including simplified SPI with no Chip Select and SPI DDR**

**Interframe message time setup permits Frame definition for support of many proprietary USART-based protocols**

**Flexible Bits/Word Decode Setup**

**Does not require clock trace to be displayed during decode**

**Use analog or digital (MSO) inputs for acquisition and triggering.**

**EXT input may be used for clock signal**
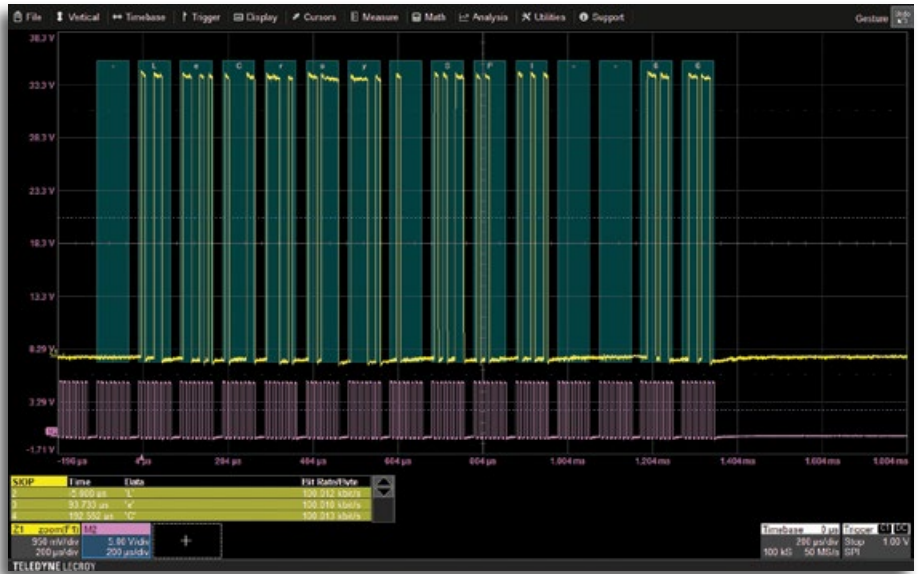


## SPI Triggering When No Chip Select is Present

Most SPI triggers require that a Chip Select signal be present. However, simplified (single-master, single-slave) SPI (also referred to as SSPI or SIOP) has no Chip Select. Our solution still permits triggering on simplified SPI through use of an Interframe Setup time. In most cases, the AUTO default provides accurate results, but MANUAL selection is also available.

## Interframe Message Time Setup for Proprietary USART-based Protocols

Two line (CLOCK and DATA) serial data signals with proprietary formats are sometimes used. This is commonly known as a USART.  Given the flexibility of the setup of our trigger and decoder, it is often possible to use the Interframe Message Time Setup to "packetize" consecutive bytes into one Message Frame, and then trigger on serial data in a particular byte location in the complete multi-byte Frame. Then, SPI-CUSTOM may be used to decode information as a complete Frame instead of individual Bytes.
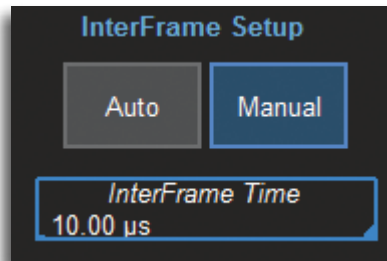
# SPECIFICATIONS

| SPIbus TD and SPIbus TDME | |
|---|---|
| **Definition** | |
| **Source and Protocol Setup** | Select Source for Clock, Data, and Chip/Slave Select (Chip/Slave Select not required for SIOP or SSPI types). Select SPI Type (SPI, SIOP, SSPI, or SPI-DDR). SPI Type CUSTOM is also available in the decoder. For SPI or SPI-Custom, select CPOL (Clock Polarity 0 or 1) and CPHA (DATA Polarity 0 or 1) (SIOP permits CPOL selection of 0 or 1, but CPHA =1; SSPI CPOL=1, CPHA=1; SPI-DDR does not have CPOL or CPHA selection). Select DATA = MSB or LSB. Select InterFrame Setup to Auto or Manual. |
| **Trigger Capability** | |
| **Format** | Hexadecimal or Binary |
| **Trigger Setup** | Trigger on DATA for any of the five SPI Modes with either MSB/LSB and with or without Slave Select. InterFrame Setup permits user-definition of expected maximum time between clock bits so as to permit triggering with CLOCK and DATA signals in the absence of a CHIP/SLAVE SELECT signal (SIOP or SSPI). Typically, the InterFrame AUTO default of 4x a bit length is sufficient, but this can be set to any value. |
| **DATA Setup** | Hexadecimal: # Data Bytes = 0 to 12. Data can be defined by nibble. Binary: Any combination of 0,1, or X for 1-96 bits<br><br>Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.<br><br>InterFrame Time Setup is available for SIOP, SSPI, and SPI-CUSTOM Types. This permits user-definition of expected maximum time between clock bits so as to permit decoding in the absence of a Chip/Slave Select signal. The InterFrame AUTO default of 4x a bit length is typically sufficient, but this can be set to any value up to 10 seconds. It also enables definition of multiple SPI (any Type) byte packets into a single long message package of multiple SPI Data bytes, over which up to 12 Data Bytes can be defined for triggering (as described above). |
| **DATA Condition Setup** | <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE |
| **Bit Rates** | Any, up to 25 Mb/s (typical). Auto-detected from clock signal. |
| **Trigger Input** | Any analog Channel or Digital input, or the EXT input. Clock or Chip/Slave Select may be input to EXT to conserve available analog Channels. |
| **Decode + Search Capability** | |
| **Format** | Hexadecimal, Binary, ASCII |
| **Decode Setup** | Threshold definition required. Default is to Percent amplitude. Choose to Decode address values including/not including the R/W bit in address value. |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. Clock channel may be turned OFF and data will still decode (reduces screen clutter) |
| **# of Decoded Waveforms** | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color Coding for FRAME, START/ReSTART bit, ADDR, R/W, DATA, ACK, NACK, and STOP bit. Decode information is intelligently annotated based on timebase setting. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search for Previous or Next MESSAGE or DATA Pattern in hexadecimal format. |

| SPIbus TDME only | |
|---|---|
| **Measure / Graph Capability** | |
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger) Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure. |

## Key Features

**Completely configurable UART-byte structure**

**Customizable Message Frame (multiple bytes in one Frame) for proprietary protocol triggering**

**Supports 9-bit "address" or "wakeup" mode in byte definition (triggering and decoding)**

**Supports up to 16-bit Data words for decoding**

**Binary, Hexadecimal, ASCII or Decimal decoding**

**Polarity either IdleLow or IdleHigh**

**Use analog or digital (MSO) inputs for acquisition and triggering.**
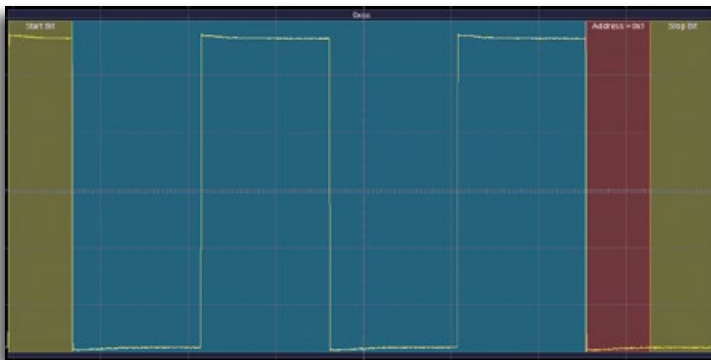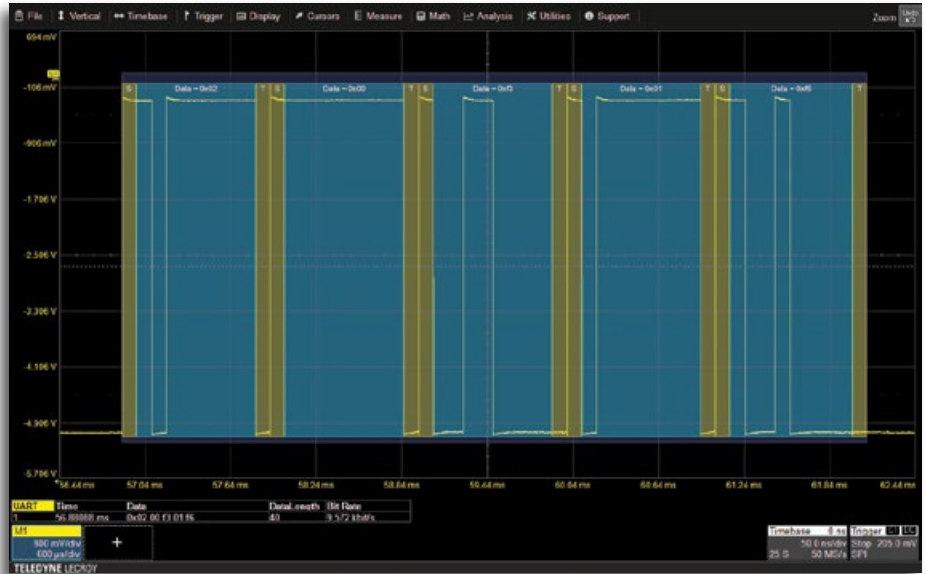


## 9-bit "Address" or "Wakeup" Triggering

Most UART triggers assume a maximum of 8 data bits (excluding stop/start and parity bits) in a single byte. However, our solution supports 9-bit data bytes for situations in which a UART protocol is utilized for Address, Wakeup or other communication to another peripheral, preceding the normal serial data byte transmission.



## Interframe Message Time Setup for Proprietary UART-based Protocols

UART byte-based serial data signals with proprietary formats are often used. Given the flexibility of the setup of our trigger and decoder, it is often possible to use the Interframe Message Time Setup to "packetize" consecutive bytes into one Message Frame, and then trigger on in serial data in a particular byte location in the complete multi-byte Frame. Then, the UART decoder may be used to decode information as a complete Frame instead of individual Bytes.



| UART | Time | Data | DataLength | Bit Rate |
|---|---|---|---|---|
| 1 | 45.12542 ms | 0x40 00 4f 59 71 | 40 | 9.615 kbit/s |
| 2 | 56.88088 ms | 0x40 00 cf 80 6f | 40 | 9.609 kbit/s |
| 3 | 68.68821 ms | 0x40 00 2f 59 09 | 40 | 9.614 kbit/s |
| 4 | 80.45641 ms | 0x40 00 af 80 1f | 40 | 9.621 kbit/s |

## UART-RS232bus TD and UART-RS232bus TDME

**Definition**

| Source and Protocol Setup | For UART:<br>Select Source for Data<br>Select BitRate<br>Select # Data Bits (5-9)<br>Select Parity (Odd, Even, None)<br>Select # Stop Bits (1, 1.5, 2)<br>Select Bit Order (MSB or LSB)<br>Select Polarity (IdleLow or IdleHigh) | For RS-232:<br>Select Source for Data<br>Select BitRate<br>Select # Data Bits (5-8)<br>Select Parity (Odd, Even, None)<br>Select # Stop Bits (1, 1.5, 2) |
|---|---|---|

**Trigger Capability**

| | |
|---|---|
| **Format** | Hexadecimal or Binary |
| **Trigger Setup** | Trigger on DATA or Parity Error |
| **DATA Setup** | Hexadecimal:<br># Data Bytes = 0 to 12.  Data can be defined by nibble.<br>Binary:<br>Any combination of 0,1, or X for 1-96 bits<br>Data pattern can be set to start at any location in the 12 Byte / 96 bit sequence.<br>"Frame" definition permits definition of UART byte packets into a single long message package through a user-defined "Interframe Time" value.  In this mode, a 12-bit Data pattern can be defined anywhere in a 2048 UART byte message frame. |
| **DATA Condition Setup** | <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE |
| **Bit Rates** | User-defined to any nominal value from 300 b/s to 10 Mb/s |

**Decode + Search Capability**

| | |
|---|---|
| **Format** | Hexadecimal, Binary, ASCII |
| **Decode Setup** | Threshold definition required.  Default is to Percent amplitude.<br>Select BitRate, # Data Bits (5 to 16), Parity (NONE, ODD, EVEN),<br># Stop Bits (1 or 2), Bit Order (MSB or LSB), and Polarity (IDLE HIGH or IDLE LOW)<br>(for RS-232, no Bit Order or Polarity setup).<br>Frame definition permits definition of UART byte packets into a single long (decoded) message package through a user-defined "Interframe Time"  value. |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color Coding for START Bit, STOP Bit, PARITY Bit, and DATA bytes.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search for Previous or Next ERROR or DATA Byte in hexadecimal format. |

## UART-RS232bus TDME only

**Measure / Graph Capability**

| | |
|---|---|
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.<br>**Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger)<br>Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data.<br>Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %**<br>Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |

**Eye Diagram Capability**

| | |
|---|---|
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use. |
| **Failure Indication and Location** | "Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

## Key Features

**Symbolic trigger setup, decode, and data extraction and graph setup using (customer-supplied) DBC file**

**Error-frame red color decode highlight**

**DATA trigger pattern setup can be less than full bytes/nibbles and can be spread across bytes**

**Conditional ID definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)**

**Supports 29-bit GM CAN Priority ID, Source ID, Parameter ID trigger and decode**



## Symbolic (DBC) File Support

CAN and CAN FD Symbolic decode options both support use of a customer-supplied DBC file for signal selection for triggering and CAN to Value serial data DAC setup. Additionally, the decode annotation is in Symbolic format as well, with complete message and signal structures described.



## Trigger Flexibly Across Data Bytes

CAN remains the most used vehicle serial data bus. Many vehicle bus software architectures are very message dense, and data for a single message is spread across multiple data bytes. The hexadecimal and measurement toolsets permit isolation of specific bit-level data patterns in one or more data bytes, e.g., data location in bits 17-28 in data bytes 3, 4, and 5. This provides significant advantages in isolating the exact information or behavior you need. Symbolic message/signal setup is even simpler.

# SPECIFICATIONS

| | CANbus TD, CAN FDbus TD, CANbus TDME, CAN FDbus TDME | CANbus TDME Symbolic, CAN FDbus TDME Symbolic |
|---|---|---|
| **Definition** | | |
| **Protocol Setup** | CANbus and CAN FDbus: Select Source. Select BitRate and Data BitRate. CAN FDbus Only: Select Frame Type (EDL) Both (X), CAN Standard (0), or CAN FD (1). For CAN FD, select ISO FRAME, and BR Select (BRS) Both(X), Normal(0), or FD(1). | |
| **Trigger Capability** | | |
| **Format** | Hexadecimal or Binary. ID and DATA can be set up with different formats. | ID: Symbolic, Hexadecimal, Binary. DATA: Symbolic, Hexadecimal or Binary. ID and DATA can be set up with different formats. |
| **Trigger Setup** | Trigger on ID, ID+DATA, REMOTE, ERROR, or ALL (Data, Remote, or Error Frame) frames. Set Requested (Bit) Sampling Point from 20 to 90% (Basic) or set values for Prop Seg, Phase_Seg1, Phase_Seg2, and SJW for (Advanced). | |
| **ID Setup** | **Hexadecimal or Binary:** Specify STD (11-bit) or EXT (29-bit) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus. | **Symbolic**: Specify a Message to trigger on using customer supplied DBC database file. Choose from list sorted by Node, Message, or Signal. GM CAN compatible (Priority ID, Parameter ID, Source ID). **Hexadecimal or Binary:** Specify STD (11-bit) or EXT (29-bit) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus. |
| **DATA Setup** | **Hexadecimal:** # Data Bytes = 0 to 8 (CAN) or 0-12. (CAN FD) Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-64 (CAN) or 0-96 (CAN FD) bits Data pattern can be any length and can be set to start at any location in the up to 8 (CAN) or 12 (CAN FD) Byte / 64 (CAN) or 96 (CAN FD) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data. | **Symbolic:** Message+Signal with Signal value set in scaled units as defined in customer supplied DBC database file. **Hexadecimal:** # Data Bytes = 0 to 8 (CAN) or 0-12. (CAN FD) Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-64 (CAN) or 0-96 (CAN FD) bits Data pattern can be any length and can be set to start at any location in the up to 8 (CAN) or 12 (CAN FD) Byte / 64 (CAN) or 96 (CAN FD) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data. |
| **DATA Cond. Setup** | <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE | |
| **Error Frame Setup** | Select any combination of All Error Frames, Stuff Bit Errors, CRC Mismatch Errors. In CAN FDbus, also select Stuffbit Counter Error and Stuffbit Counter Parity Error. | |
| **Remote Frame Setup** | Supported for ID. Capability identical to ID Condition Setup. | |
| **Bit Rates** | Nominal Bit Rate: 10, 25, 33.333, 50, 83.333, 100, 125, 250, 500 kb/s, or 1 Mb/s pre-defined nominal values, or user-defined from 10 kb/s to 1 Mb/s. CAN FD Data Bit Rate: 0.5, 1.0, 1.5, 2.0, 5.0, 8.0, or 10 Mb/s pre-defined nominal values, or user-defined to any nominal value from 0.5 to 10 Mb/s. | |
| **Trigger Input** | Any analog Channel or Digital input, or the EXT input. | |
| **Decode + Search Capability** | | |
| **Format** | Hexadecimal | Symbolic (Message and Signal level) or Hexadecimal. Symbolic decode requires user-provided DBC database file. |
| **Decode Setup** | Threshold definition required. Default is to Percent amplitude. Select bit rate(s). | |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. | |
| **# of Decode Wfms** | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). | |
| **Visual Aid** | Color Coding for FRAME, ID, IDE, EDL, BRS, ESI, RTR, DLC, DATA, CRC, ACK, STUFF BITS, BIT INDEX, and ERRORS. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. | Color Coding for FRAME, ID, IDE, EDL, BRS, ESI, RTR, DLC, DATA, CRC, ACK, STUFF BITS, BIT INDEX and ERRORs. Symbolic includes textual Message name and physical Signal value with units. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. | |
| **Pattern Search** | Search for Previous or Next Index, ID, IDE, DLC, DATA, and STATUS | |

## CANbus TDME, CANbus TDME Symbolic, CAN FDbus TDME, CAN FDbus TDME Symbolic only

| | |
|---|---|
| **Measure / Graph Capability** | |
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %**. Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure. |

## Key Features

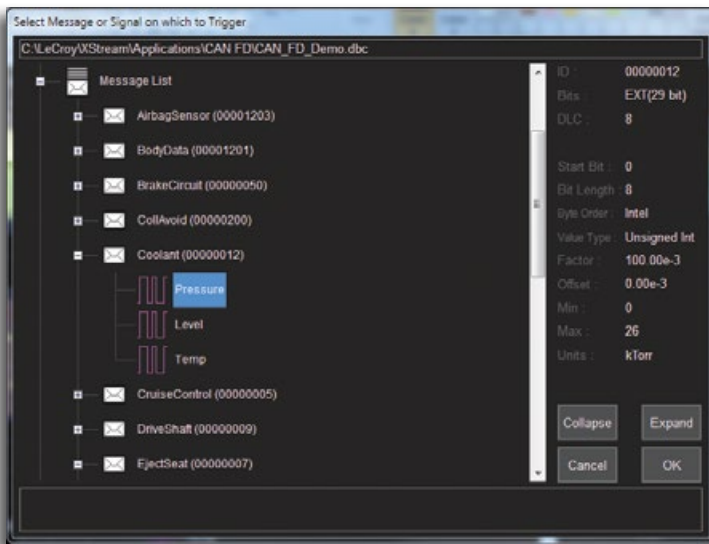**LIN 1.3, 2.x and J2602 support**

**Break (Start of Message), ID, ID+DATA, and Error Frame triggers**

**Error-frame red color decode highlight**

**Error-frame trigger can include some or all of Checksum, Header Parity, or Sync Byte types.**

**Conditional ID definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)**

**Supports decode of buses with mixed LIN version traffic**
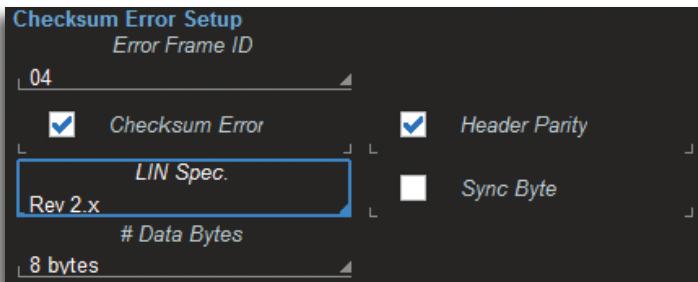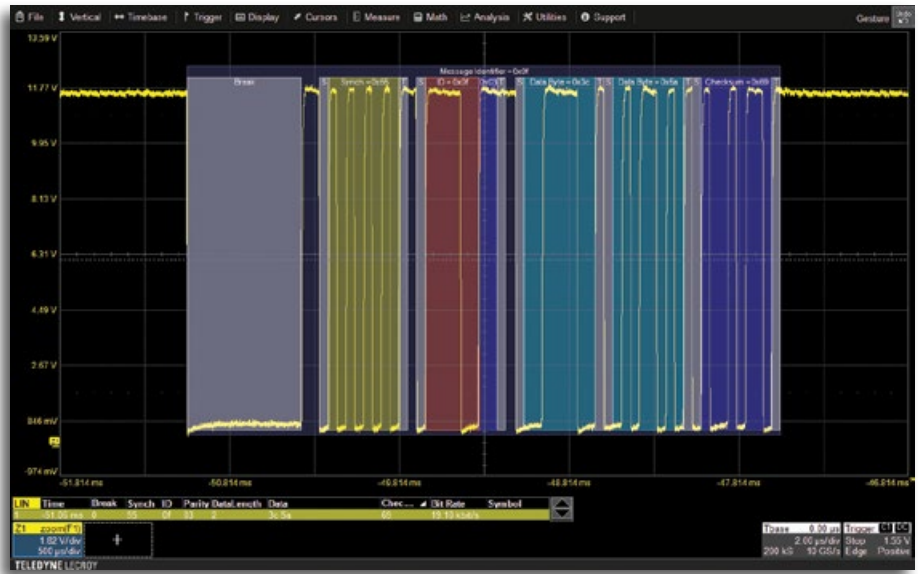


## Flexible Error Frame Trigger

Select to trigger on any combination of Checksum, Header Parity, or Sync Byte error frame types. Additional, Checksum Error allows further definition for Frame ID, LIN Version, and Number of Data Bytes.



## Trigger Flexibly Across Data Bytes

Many vehicle bus software architectures are very message dense, and data for a single message is spread across multiple data bytes. Our LIN trigger and measurement toolsets permit isolation of specific bit-level data patterns in one or more data bytes, e.g., data location in bits 18-26 in data bytes 2 and 3. This provides significant advantages in isolating the exact information or behavior you need.
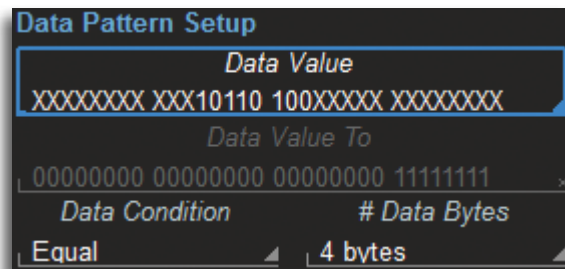
# SPECIFICATIONS

| LINbus TD and LINbus TDME | |
|---|---|
| **Definition** | |
| Source and Protocol Setup | Select Source.  Select BitRate. |
| **Trigger Capability** | |
| Format | Hexadecimal or Binary |
| Trigger Setup | Trigger on (Sync) Break (Start of Message), Frame ID, Frame ID+DATA, Error Frame (Any combination of Checksum, Header Parity, or Sync Byte error frames) |
| ADDRESS Setup | Specify one ADDRESS with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. |
| DATA Setup | Hexadecimal:<br># Data Bytes = 0 to 8.  Data can be defined by nibble.<br>Binary:<br>Any combination of 0,1, or X for 1-64 bits<br>Data pattern can be any length and can be set to start at any location in the up to 8 Byte / 64 bit sequence. |
| DATA Condition Setup | <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE |
| Error Setup | Select any combination of Checksum Error, Header Parity, or Sync Byte types.<br>Checksum Error Setup for Frame ID, LIN version, and # Data Bytes |
| Bit Rates | 1.2, 2.4, 4.8, 9.6, 10.417, 19.2 kb/s pre-defined nominal values,  or user-defined to any nominal value from 300 b/s - 20 kb/s. |
| Trigger Input | Any analog Channel or Digital input, or the EXT input. |
| **Decode + Search Capability** | |
| Format | Hexadecimal, Binary |
| Decode Setup | Threshold definition required.  Default is to Percent amplitude.<br>Select BitRate.  Select LIN version (1.3, 2.x, J2602, ALL).  Decodes LIN messages on busses with mixed LIN versions |
| Decode Input | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| Visual Aid | Color Coding for FRAME, BREAK, START/STOP bits, SYNCH bits, ID, ID Parity, DATA, CRC.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| Table Configure, Export Table | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information.   Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| Pattern Search | Search by Previous or Next Frame, Next ID (hexadecimal format), or Next Error Frame. |

| LINbus TDME only | |
|---|---|
| **Measure / Graph Capability** | |
| Serial Data Digital-to-Analog Conversion (DAC) | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.<br>**Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| Timing Measurements | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger)<br>Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data.<br>Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| Bus Status Measurements | **Number of Messages, Message Bit Rate, Message Bus Load %**<br>Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| Setup | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| Eye Parameters | Eye Height, Eye Width, (Number of) Mask Hits |
| Eye Mask | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use. |
| Failure Indication and Location | Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

## Key Features

**The most comprehensive oscilloscope-based FlexRay solution**

**Supports triggering for:**
- Frame ID (Static and Dynamic)
- Frame Cycle Count
- Frame Qualifiers
- Symbols
- Errors

**Physical Layer Measurements**
- Propagation Delay
- Asymmetric Delay
- Truncation
- Jitter
- SI Voting

**Supports 2.5, 5 and 10 Mb/s signals**



## Extensive Triggering Capabilities

Triggering on the complex FlexRay protocol is made easy. Set up a simple TSS (Start) symbol trigger with a single button press or trigger on any part of a FlexRay frame including ID, Cycle Count, Cycle Repetition Factor, and Frame Qualifier. FlexRay defined Symbols and Errors can also be incorporated into the trigger making it as simple or advanced as necessary. Conditional triggering can be set to trigger on any range of Frame IDs or Cycles.

## Powerful Physical Layer Test

FlexRay eye diagram mask test overlays all the bits on FlexRay signal in an eye diagram with user-selected masks. Trigger on a specific Frame ID or range of IDs, or filter one long acquisition specific IDs, and show only those messages in the eye diagram. Supports SI Voting. Key timing parameters like Propagation Delay, Asymmetric Delay, Truncation and Jitter help you understand how signals propagate along the channel. Use statistics and histicons for deeper insight..
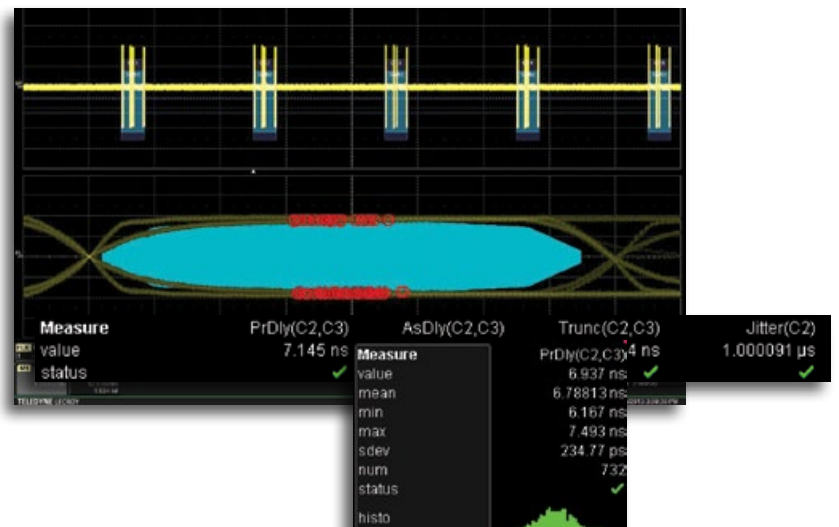
# SPECIFICATIONS

| FLEXRAYbus TD and FLEXRAYbus TDMP | |
|---|---|
| **Definition** | |
| **Source and Protocol Setup** | Select Source.  Select BitRate.<br>Select FlexRay Channel A or Channel B. |
| **Trigger Capability** | |
| **Format** | Hexadecimal or Binary for Frame ID.<br>Decimal for Cycle Count. |
| **Trigger Setup** | Trigger on TSS (Start), Frame ID, Cycle Count, Symbols, and Errors |
| **FRAME Setup** | Specify Frame ID(s) in Hexadecimal or Binary with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.<br>Specify Cycle Count from 0 to 63 with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE.  Specify Repetition Factor as 1, 2, 4, 8, 16, 32, or 64.<br>Specify various Frame Qualifiers (Payload Preamble, Null Frame, Sync Frame, and Startup Frame) as 0, 1, or X (don't care). |
| **DATA Setup** | Hexadecimal:<br># Data Bytes = 0 to 8.  Data can be defined by nibble.<br>Binary:<br>Any combination of 0,1, or X for 1-64 bits<br>Data pattern can be any length and can be set to start at any location in the up to 8 Byte / 64 bit sequence. |
| **Error Setup** | Trigger on any combination of the following errors:<br>Frame Start Sequence (FSS) Error – triggers when the logic high time between the TSS and the first byte is too long. Byte Start Sequence (BSS) Error – triggers anytime the BSS pattern is not seen between bytes where expected.<br>Frame End Sequence (FES) Error – triggers when the FS is not seen after the last byte.<br>Header CRC Error, Payload CRC Error (select Payload Channel A or B). |
| **Symbol Trigger** | Trigger on any combination of the following:<br>Channel Idle Delimiter (CID) Symbol, Collision Avoidance Symbol (CAS) and/or Media Access Test Symbol (MTS), or Wakeup Pattern (WUP) |
| **Bit Rates** | 2.5, 5, or 10 Mb/s pre-defined nominal values, or user-defined nominal values in 1 Mb/s increments |
| **Trigger Input** | Any analog Channel or the EXT input. |
| **Decode + Search Capability** | |
| **Format** | Hexadecimal, excepting Cycle Count (Decimal) |
| **Decode Setup** | Threshold definition required for High and Low levels.  Default is to Absolute (in volts) amplitude.  Select Channel (A or B). |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color Coding for FRAME, TSS, CID, FSS, Frame Qualifiers, Slot ID, Payload Length, Header CRC, Cycle Count, Data, BSS, Payload CRC and FES.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information.   Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search by Previous or Next Frame, Next ID (hexadecimal format), or Next Error Frame. |

| FLEXRAYbus TDMP only | |
|---|---|
| **Measure / Graph Capability** | |
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.  **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger).  Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data.  Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %.**  Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | FlexRay PHY: Supports SI Voting (ON or OFF).  With SI Voting ON,  with voting selection for Positive Bit Length, Negative Bit Length (or both), and Filtered Input is possible.  With SI Voting OFF, Any combination of Propagation Delay, Asymmetric Delay, Frame TSS Length Change, or Jitter.<br>Eye Diagram: Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use.  Standard FlexRay TP1, TP1 Bus Driver, TP11, and TP11 Active Star are also provided. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

## Key Features

**Symbolic decode with user-provided ULDF database file**

**Decode Viewing Control Selection**
- 8+24
- 8+2+19+2+1
- User-defined

**Decode Annotation includes:**
- Frame
- ID
- Label
- Raw Bits
- SDI
- Data
- SSM
- Parity
- Symbolic Message and Symbols
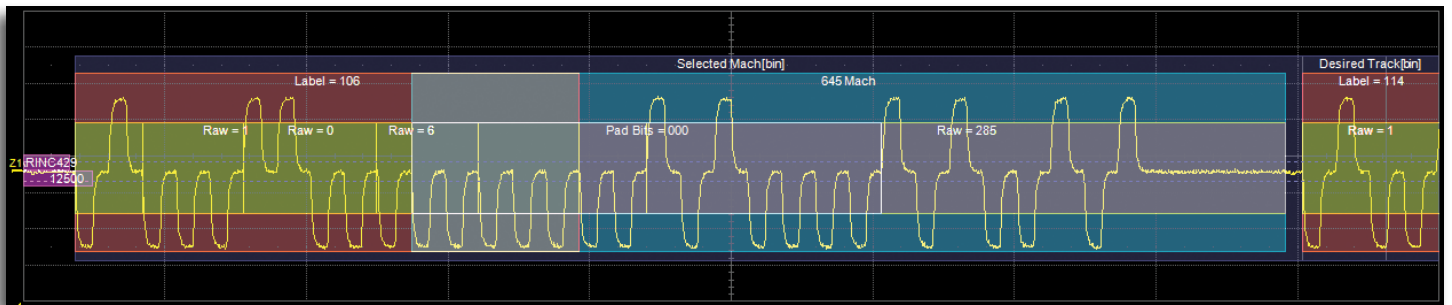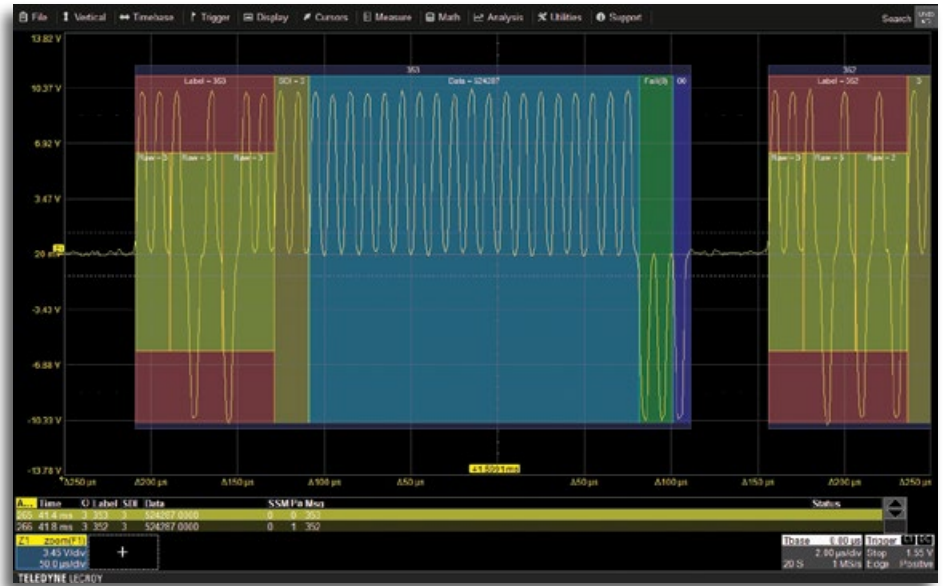




## Symbolic Decode Transparent Overlay

A unique and powerful way to view decoded data. Using a user-provided ULDF file, the label and equipment ID fields can be displayed in an intuitive and easy to interpret way. The ULDF Label file is a Comma Separated Variable (CSV) file that contains the ARINC429 token definitions. Any text editor can be used to create or modify the Label file, and there is no limitation as to how many signals can be defined for a given Label. Here, the specified converted data is Selected Mach = 645 Mach.

## Symbolic Decode Protocol Table

Symbol data is then displayed in the protocol table. Quickly view valuable information for each ARINC 429 word, such as Label, SDI, Data, SSM, Parity, and Symbolic Message.

| Data | SSM | Pa | Msg | Symbols | Bits/Resol... | Pad |
|---|---|---|---|---|---|---|
| 645 Mach | | | | Selected Mach[bin] | 12 / 1.000000 | 0 |
| 17.6 Degrees | | | | Desired Track[bin] | 12 / 0.050000 | 13 |
| 550 mDegrees | | | | VS/FPA Val[bin] | 12 / 0.050000 | 6 |
| 96 None | | | | TACAN Control[bin] | 12 / 1.000000 | 0 |
| 0.0 m | | | | Metric Altitude[bcd] | 4 / 0.250000 | 0 |
| 30.0 kg/m2 | | | | Appr Loc[bcd] | 4 / 0.250000 | 0 |
| 5.0 kg/m2 | | | | DD5[bcd] | 4 / 0.250000 | 0 |
| 1.01e+3 | | | | Spare[bin] | 10 / 1.000000 | 464 |
| 63 — | | | | Spare[bin] | 10 / 1.000000 | 507 |

| ARINC429Bus DSYMBOLIC and ARINC429Bus DMESYMBOLIC | |
|---|---|
| **Definition** | |
| **Source and Protocol Setup** | Select Source.  Select BitRate. |
| **Decode + Search Capability** | |
| **Format** | Hexadecimal or Symbolic+Hexadecimal.  Symbolic decode requires user-provided ULDF database file |
| **Decode Setup** | Threshold definition required for High and Low levels.  Default is to Absolute (in volts) amplitude.  Select Viewing Control (8+24, 8+2+19+2+1, or User-defined). |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color coding for Frame, ID, Label, Raw Bits, SDI, Data, SSM, Parity.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information.   Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search for Previous or Next IDX, Time, OctalDigits, Label, SDI, Data, SSM, Parity, Msg, or Status |

| ARINC429Bus DMESYMBOLIC only | |
|---|---|
| **Measure / Graph Capability** | |
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.<br><br>**Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger)<br><br>Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data.<br><br>Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %**<br><br>Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

# USB 2.0

## Key Features

**Supports USB 2.0 Low, Full, or High speeds (1.x and 2.0)**

**Trigger on USB packet types:**
- Token
- Data
- Handshake
- User-defined

**Transaction triggering support**

**Comprehensive Protocol Error and Bus Event triggering**

**Comprehensive Search by Events, Packets, Transactions or Errors**





## The Most Comprehensive USB Trigger

Full support is provided for triggering on any type of Packet, even User-Defined Packets, with complete flexibility for address, endpoint, split type, hub, port, etc. Trigger on specific Data payloads in specific locations. OR any three Packets in a single trigger condition. Create a USB Transaction trigger with any allowed combination of Token, Data, Handshake, and User-Defined packets. Advanced capability like this is usually only found in a dedicated protocol analyzer!

## Search and Zoom

The powerful search engine of the USB 1.x/2.0 decode package can quickly find an Event, Packet, Transaction, or Protocol Error. Search through a long record of decoded data by entering any of the 45 available search criteria by entering a value or simply finding the next occurrence. For example, search through a long record to find a glitch that is frequently occurring after each EOP.

## USB2bus TD and USB2bus TDME

### Definition

| | |
|---|---|
| **Source and Protocol Setup** | Select for USB Low, Full, or High Speeds (1.x and 2.0). Select Source(s) (one or more, depending on Speed and probing system used). Select D+ and D- Voltage Levels (Low and Full Speeds only) |

### Trigger Capability

| | |
|---|---|
| **Format** | Hexadecimal or Binary |
| **Trigger Setup** | Trigger on Packet Type (Any, Token, Data, Handshake, or User-Defined), Protocol Error, Transaction (combine any allowable set of Token, Data, Handshake or User-defined Packet together in a Transaction), or Bus Event |
| **PACKET Setup** | **Any Packet:** Trigger on ANY SYNCH pattern. **Token Packet:** Trigger on ANY Token Packet. Select PREAMBLE/ERR Token Packet. Select SOF Token Packet with specific Frame Number. Select OUT, IN, SETUP, or PING Token Packet with a specific Address and Endpoint, or "don't care." Select SPLIT Special Token Packet with a specific SPLIT TYPE, HUB ADDR, PORT, S(speed/start), E(nd), and ET (for SPLIT type). Select USER-DEFINED. Trigger on any of three Token Packets of any type and trigger on them with an "OR" condition. **Data Packet:** Trigger on ANY Data Packet. Trigger on a single DATA0, DATA1, DATA2, or MDATA Data packet, with settings for Data Payload or Data Length, or trigger on any of up to three Data Packets of any type in an OR condition, with independent setup of Data Payload value or Data Length values. **Handshake Packet:** Trigger on ANY Handshake Packet. Trigger on a specific ACK, NAK, NYET, STALL or ERR Handshake Packet. **Transaction Packet:** Trigger on any USB Transaction - combine any allowable set of Token, Data, Handshake or User-Defined Packet together in a Transaction, and trigger when that set is detected |
| **DATA Setup** | In any DATA PACKET define up to three data conditions with OR logic. Data conditions may be Data Payload Pattern or Data Length for Any, DATA0, DATA1, DATA2, or MDATA types. Data Payload Pattern Setup (Hexadecimal): # Data Bytes = 1 to 16. Data can be defined by nibble. Data Payload Pattern Setup (Binary): Any combination of 0,1, or X for 1-128 bits. Data Payload Pattern start at any location in an up to 128 Byte / 1024 bit sequence. Data Length Setup: Hexadecimal; # Data Bytes = 0 to 1024. |
| **DATA Cond. Setup** | Data Payload: =, <>, or DON'T CARE. Data Length: <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or ANY LENGTH |
| **Error Setup** | Trigger on any ORed combination of PID/Check Error, CRC5 Error, CRC16 Error, Frame Length Error, Bad Data Toggle Error, or PID0 Error |
| **Bus Event Setup** | Trigger on any ORed combination of Reset, Resume, Suspend, or Chirp |
| **Bit Rates** | Low, Full or High-speed pre-defined values. |
| **Trigger Input** | USB 1.x and USB 2.0 (Low and Full Speed): Requires two inputs, using any analog Channels or the EXT input USB 2.0 (High Speed): Pre-defined channel, specific to each oscilloscope product line. Input must be with a suitable differential probe. |

### Decode + Search Capability

| | |
|---|---|
| **Format** | Hexadecimal USB 2.0 Link and Data Layer Protocol Decode |
| **Decode Setup** | Select Bus Speed (Low, Full, High). Select Probing Type (One Single-ended Probe, Two Single-ended Probes, Differential Probe). |
| **Decode Input** | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| **Visual Aid** | Color Coding for Transaction, Packet (Handshake, Token, or Data), Control Sequences (Synch bits, PID bits, Check bits, or EOP bits), Device Address, Endpoint, Data Payload, CRC5 o CRC7, Inter-packet Idle, Inter-transaction Idle. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| **Table Configure, Export Table** | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| **Pattern Search** | Search for Event, Token Packet, Data Packet, Handshake Packet, Transaction Packet, or Protocol Error (45 unique conditions) |

## USB2bus TDME only

### Measure / Graph Capability

| | |
|---|---|
| **Serial Data Digital-to-Analog Conversion (DAC)** | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| **Timing Measurements** | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| **Bus Status Measurements** | **Number of Messages, Message Bit Rate, Message Bus Load %.** Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |

### Eye Diagram Capability

| | |
|---|---|
| **Setup** | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%. |
| **Eye Parameters** | Eye Height, Eye Width, (Number of) Mask Hits |
| **Eye Mask** | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use. |
| **Failure Indication and Location** | Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure. |

## Key Features

**Most comprehensive MIL-STD-1553 oscilloscope trigger available**

- Transfers
- Command Words
- Data Words
- Status Words
- Error Words
- Response Times
- Intermessage Gap Times

**Conditional ADDRESS definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)**

**Completely isolate a specific RT Address, Sub Address, Data Value, and Mode Code**

**Support for MIL-STD-1553 versions A and B**



## Highly Flexible and Powerful Triggering

The MIL-STD-1553 trigger can be configured at the transfer or word level to provide the right level of triggering. In addition, error triggers are able to locate the cause of protocol errors at either the transfer or word level. Word level triggering allows conditional RT Address and Sub Address entry.



| MIL-STD-1553 TD and MIL-STD-1553 TDME | |
|---|---|
| **Definition** | |
| **Source Setup** | Select Source |
| **Trigger Capability** | |
| **Format** | Hexadecimal or Binary (Decimal for Word Count). |
| **Trigger Setup** | Trigger on ANY TRANSFER; a COMMAND WORD, STATUS WORD, DATA WORD, or ALL WORDS; an ERROR, a RESPONSE TIME, or an INTERMESSAGE GAP TIME.  TRANSFERS may be further qualified by selecting the message type BC-RT, RT-BC, RT-RT, MODE COMMAND, MODE COMMAND & DATA (XMIT), MODE COMMAND AND DATA (RCV), various BROADCASTS (BC-RT(S), RT-RT(S), MODE COMMAND, and MODE COMMAND AND DATA) |
| **Address Setup** | For COMMAND WORD trigger specify 5-bit Remote Terminal (RT) Address ID(s) or Sub Address(es) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE; specify Transmit/Receive bit setting of 0, 1, or X (don't care).<br>For STATUS WORD trigger, specify 5- bit RT Address(es)  ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE; Specify Status Word bits as 0, 1, or X (don't care) for Message Error, Instrumentation, Service Request, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance, or Terminal Flag.<br>For any TRANSFER containing an RT Address or Sub Address, setup is identical to that specified above.<br>Settable in Hexadecimal or Binary format in all cases. |

| MIL-STD-1553 TD and MIL-STD-1553 TDME (Cont'd) | |
|---|---|
| DATA Setup | Data Word Count: In any TRANSFER, specify Data Word Count in decimal format up 32 data words.<br>DATA WORD or TRANSFER Data Setup (Hexadecimal): # Data Bytes = up to 2 (one Data Word) byte length, settable by nibble.<br>DATA WORD or TRANSFER Data Setup (Binary): Any combination of 0,1, or X for 1-16 bits.<br>Data pattern can be set to start at any location in an up to 2 Byte / 16 bit sequence (in a DATA WORD) or an up to 64 Byte / 512 bit sequence (in a TRANSFER) |
| DATA Condition Setup | Data Word Count: <=, <, =, >, >=, or <><br>Data Setup: <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE |
| Mode Command Setup | TRANSFER MODE COMMANDS and COMMAND WORDS may be qualified by selecting a Mode Code (0 to 31, with description) with a Mode Code condition of <=, <, =, >, >=, or <>. |
| Status Setup | In any TRANSFER or STATUS WORD, select 0, 1, or X (don't care) for various Status Word bits. Select for: Message Error, Instrumentation, Service Request, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Acceptance, and Terminal Flag |
| Error Setup | Select one or more Word Level or Transfer Level errors using a check box.  Word Level error selection: Invalid Sync, Manchester Error, Idle Error, Parity Error.  Transfer Level error selection: Bad Word Count, Address Mismatch, Non-contiguous Data, Sync Error. |
| Other Setups | Response Time Setup: Conditional Setup <, >, in range, out of range; Value Setup: 0 to 32.752 microseconds.<br>Intermessage Gap Setup: Conditional Setup <, >, in range, out of range; Value Setup: 0 to 32.752 microseconds. |
| Bit Rates | 1 Mb/s, pre-defined nominal value |
| Trigger Input | Any analog Channel or the EXT input. |
| **Decode + Search Capability** | |
| Format | Hexadecimal, Binary, Decimal (Binary not available for Address). |
| Decode Setup | Threshold definition required for High and Low levels.  Default is to Absolute (in volts) amplitude.   Select Table (Display) Mode (WORD or TRANSFER).  Define Response Time and InterMessage Gap Time limits. |
| Decode Input | Any analog Channel, Memory or Math trace, and any Digital trace. |
| # of Decodes | Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information). |
| Visual Aid | Color Coding for Message, Word, Sync bits, RTA Address and SubAddress bits, Receive/Transmit bit, Data Count  bits, Data (Payload) bytes and Single-bit Condition Codes, Reserved bits, Response Time Check and Inter-Message Gap Time, and Word and Transfer Level Error Codes.<br>Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform. |
| Table Configure, Export Table | Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table.  Displayed information includes Index, Timestamp, and other various protocol-specific information.   Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns. |
| Pattern Search | Search for Previous or Next Index, Time, Message, Transaction, Type, Summary, Sync, RT Address, T/R, SubAddress, Count, ModeCode, Parity, Response Time, RT Address ACK, Message Error, Inst, SRQ, Reserved, Broadcase Rx, Busy, SubSystem Flag, Dynamic Bus Access, Terminal Flag, Data, IMG, or Status |


| MIL-STD-1553 TDME only | |
|---|---|
| **Measure / Graph Capability** | |
| Serial Data Digital-to-Analog Conversion (DAC) | **Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value.  Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion.  **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time. |
| Timing Measurements | **Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger).  Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data.   Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements. |
| Bus Status Measurements | **Number of Messages, Message Bit Rate, Message Bus Load %**.  Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data. |
| **Eye Diagram Capability** | |
| Setup | Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s).  Eye Style selectable as color- or analog-persisted.  Eye Saturation adjustable from 0 to 100%. |
| Eye Parameters | Eye Height, Eye Width, (Number of) Mask Hits |
| Eye Mask | Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility.  Store custom masks for later recall and use. |
| Failure Indication and Location | "Mask Failure Indication ON or OFF (ON = indicated with a red circle).<br>Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table.  Supports STOP trigger on Mask Failure. |

# COMPATIBILITY

| | | WaveSurfer 3000 | WaveSurfer Xs, WaveSurfer 10, HDO4000 | WaveRunner 6 Zi, WaveRunner 8000 | HDO6000, HDO8000, MDA800 | WavePro 7 Zi, WaveMaster 8 Zi | LabMaster 9 Zi-A, 10 Zi |
|---|---|---|---|---|---|---|---|
| **Embedded Computing** | I²C | EMB bundle | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| | SPI | | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| | UART-RS232 | | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| | USB 2.0 HSIC | - | D | D | D | D | D |
| | EMB bundle (I²C, SPI, UART-RS232) | TD | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| **Automotive + Industrial** | CAN | AUTO bundle | TD | TD, TDME, TDME Symbolic | TD, TDME, TDME Symbolic | TD, TDME, TDME Symbolic | D, DME[1], DME Symbolic[1] |
| | CAN FD | TD | TD | TD, TDME, TDME Symbolic | TD, TDME, TDME Symbolic | TD, TDME, TDME Symbolic | D, DME[1], DME Symbolic[1] |
| | FlexRay | TD | TD | TD, TDMP | TD, TDMP | TD, TDMP | D, DMP[1] |
| | LIN | AUTO bundle | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| | SENT | D | D | D | D | D | D |
| | AUTO bundle | TD[4] | TD[4] | - | - | - | - |
| **Avionics** | ARINC 429 | - | D Symbolic | D Symbolic, DME Symbolic | D Symbolic, DME Symbolic | D Symbolic, DME Symbolic | D Symbolic, DME Symbolic[1] |
| | MIL-STD-1553 | - | TD | TD, TDME | TD, TDME | TD, TDME | D, DME[1] |
| | SpaceWire | - | D | D | D | D | D |
| **Peripherals** | Ethernet (10/100Base-T) | - | D | D | D | D | D |
| | USB 2.0 | - | D | TD, TDME | TD, TDME | D, DME | D, DME[1] |
| **MIPI** | DPHY | - | D | D, DP[5] | D | D, DP[5] | D, DP |
| | DigRF 3G | - | D | D, DM[3] | D, DM[3] | D, DM[3] | D, DM[3] |
| | DigRF v4 | - | D | D, DM[3] | D, DM[3] | D, DM[3] | D, DM[3] |
| **Other** | Audio (I²S, LJ, RJ, TDM) | - | TD | TD, TDG | TD, TDG | TD, TDG | D, DG[1] |
| | Manchester | - | D | D | D | D | D |
| | NRZ | - | D | D, TD[2] | D | D, TD[2] | TD[2] |

## Customer Service

Teledyne LeCroy oscilloscopes and probes are designed, built, and tested to ensure high reliability. In the unlikely event you experience difficulties, our digital oscilloscopes are fully warranted for three years and our probes are warranted for one year. This warranty includes:

- No charge for return shipping
- Long-term 7-year support
- Upgrade to latest software at no charge

**TELEDYNE LECROY**
Everywhere**you**look™

**1-800-5-LeCroy**
teledynelecroy.com

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